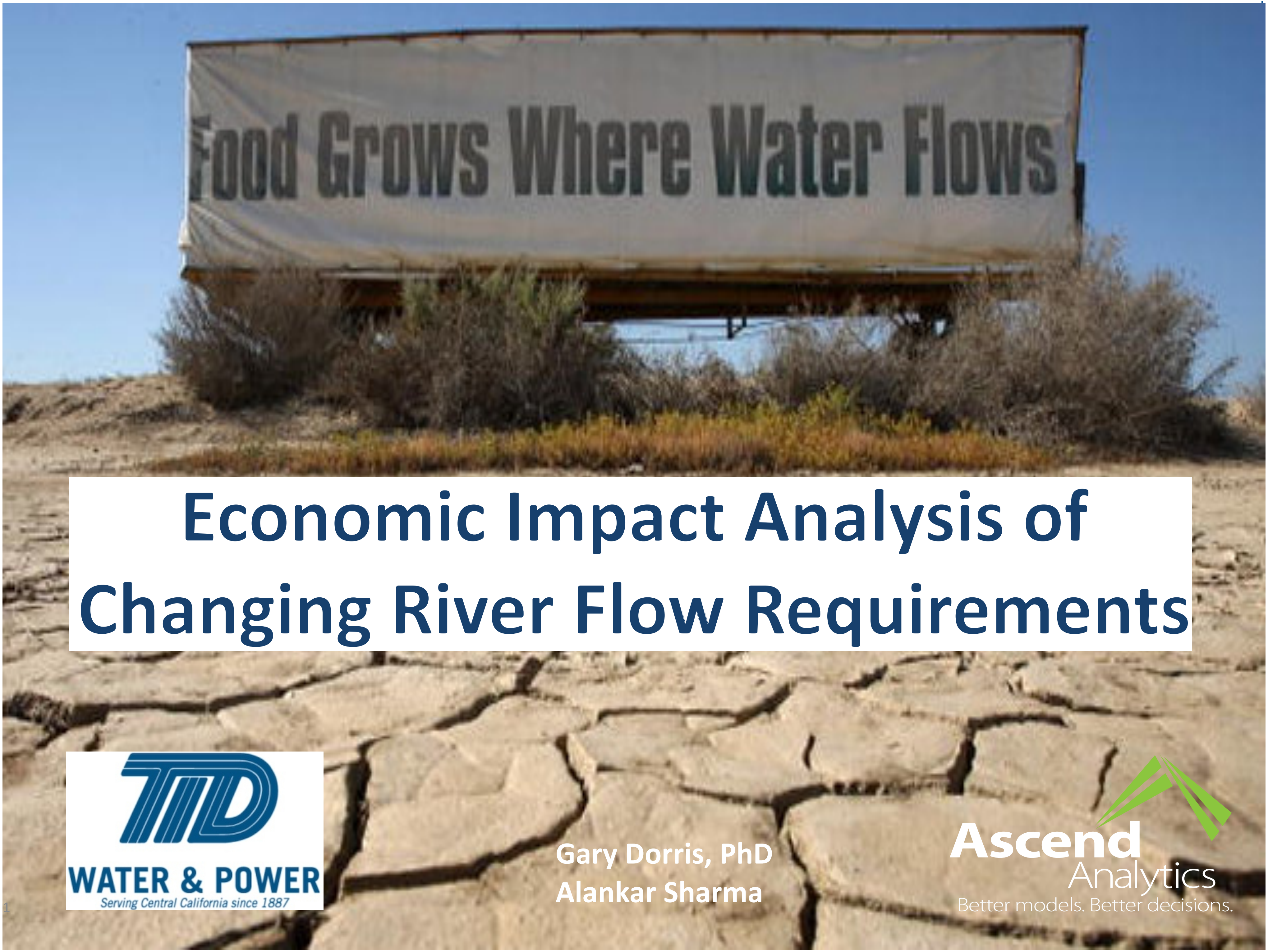


# Economic Impact Analysis of Changing River Flow Requirements

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Gary Dorris, PhD
Alankar Sharma

Ascend Analytics
Better models. Better decisions.

# Fundamentally Flawed River Flow Requirement Proposals

Increased water diversions will adversely affect
local communities, property values,
revenues and taxes, local agriculture,
and the statewide economy.

As a result,
the three river flow requirements proposals
(NMFS, USFWS, and CDFW—all fundamentally flawed)
must not be implemented.

Farmers deserve—and must have—water rights!

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# Agriculture Analysis of River Flow Requirements

Turlock Irrigation District retained Ascend as an independent economic consultant to estimate the direct and secondary effects of newly proposed river flow requirements on the value of agriculture in TID. This presentation contains an objective assessment of the economic damages to TID that would be caused under the proposals for river flows drafted by:

- National Marine Fisheries Service (NMFS)
- US Fish and Wildlife Services (USFWS)
- California Department of Fish and Wildlife (CDFW)

# Our Major Points

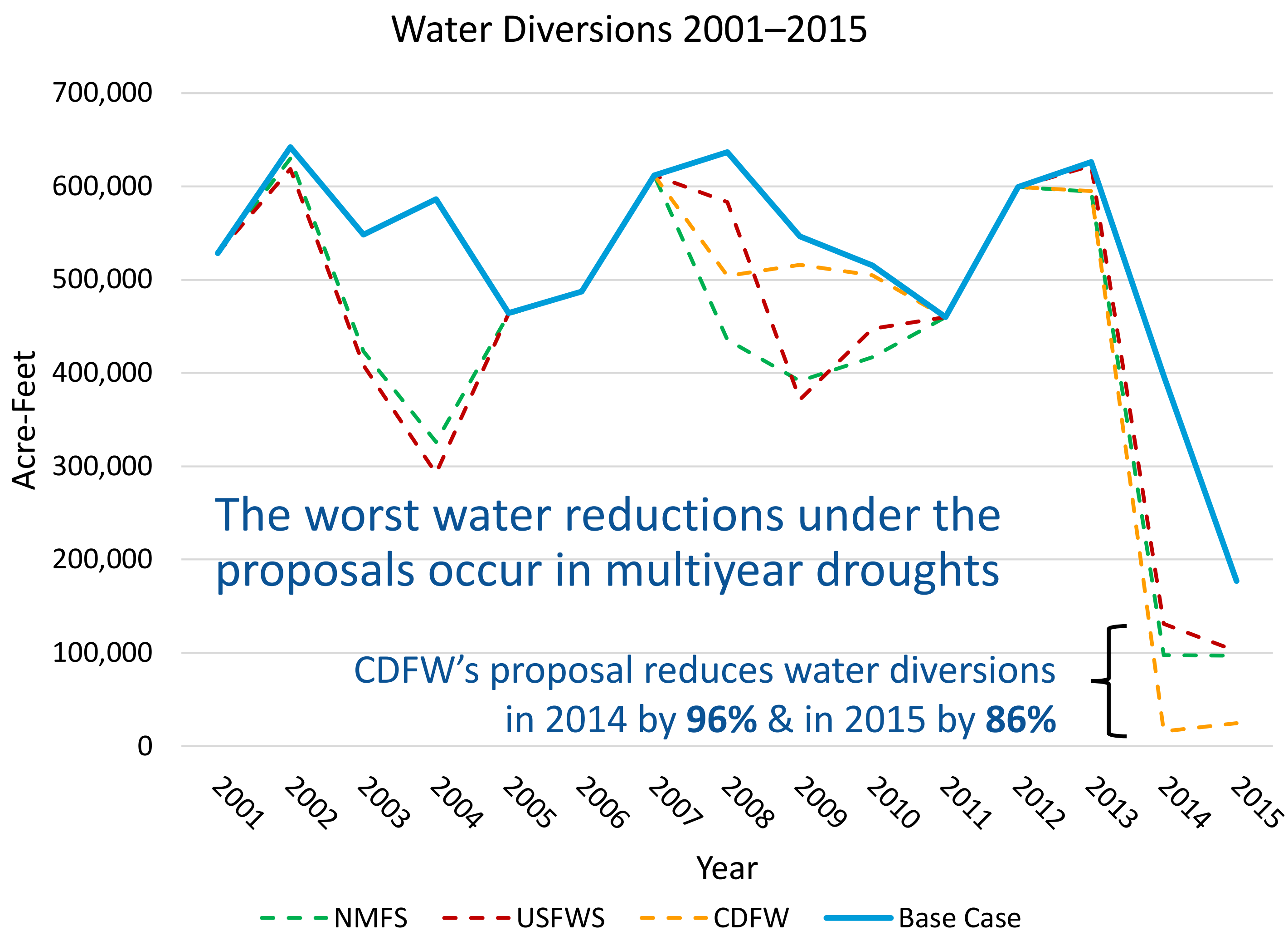
- **Our Analysis:** Study timeline for two valuation analysis approaches: Ascend and UC Davis IMPLAN Multiplier
- **The Larger Picture:** Local and state agriculture significance and economic impact
- **Three Flawed River Flow Requirements:** Flawed and incomplete proposals reduce water flow that adversely affects the agricultural economy
- **Agricultural and Economic Consequences:** Greater water variability leads to crop reductions and devaluation; agricultural losses; dairy losses; population migration; and property value, income, and revenue losses.
- **Financial Losses:** $287 Million to $408 Million loss *annually*

# Our Analysis

Study timeline for two valuation analysis approaches:
Ascend and UC Davis IMPLAN Multiplier

# Ascend Study Timeline

- Ascend's analysis takes place over a 15-year historical timeline, super-imposing current agricultural values and crop mixes
- Three droughts in Ascend timeline:
  - 2001–2002
  - 2007–2009
  - 2012–2015




Applied Water was determined by scaling results from TID's analysis on water diversions to DWR's historical data on applied water for the region

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# Ascend Economic Valuation Approach

- Accounts for the ripple effects that occur after a drought, building upon the previous UC Davis IMPLAN multiplier for upfront agricultural damages
- Accounts for the irreversible damage to tree crops and agriculture business under critical drought years
- Identifies a dollar value on the change in population after a drought
- Identifies a multitude of adverse effects on tax revenue, property values, regional income loss, and the dairy industry


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# The Larger Picture

Local and state agriculture significance and economic impact

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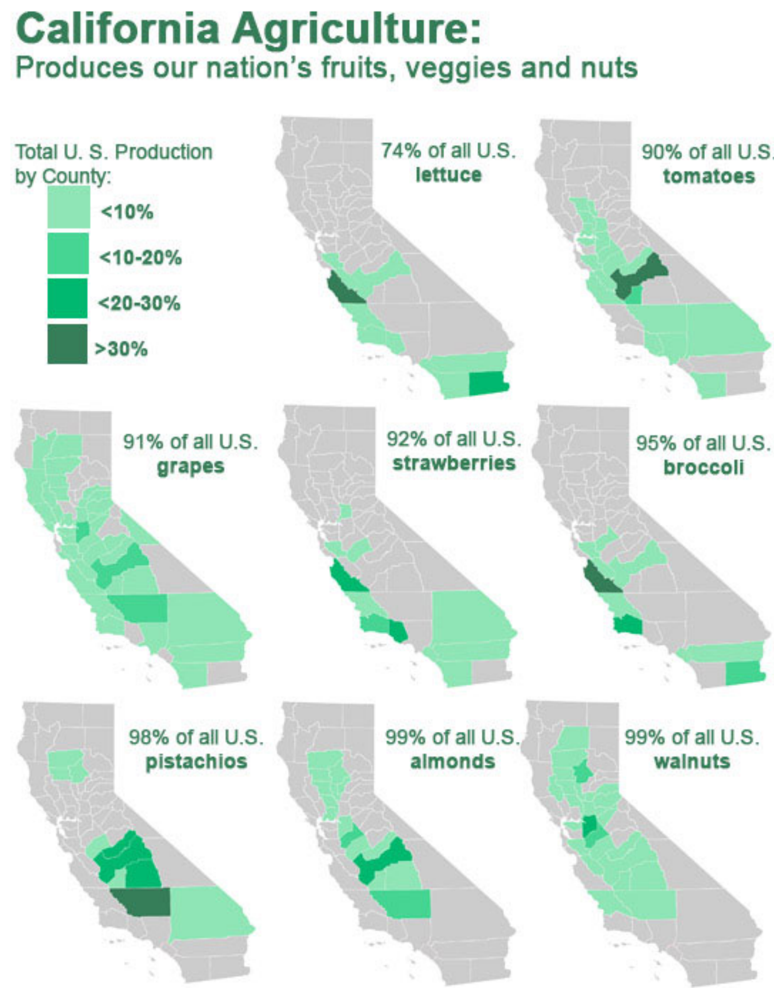
# California: Significant Impact on National Industry

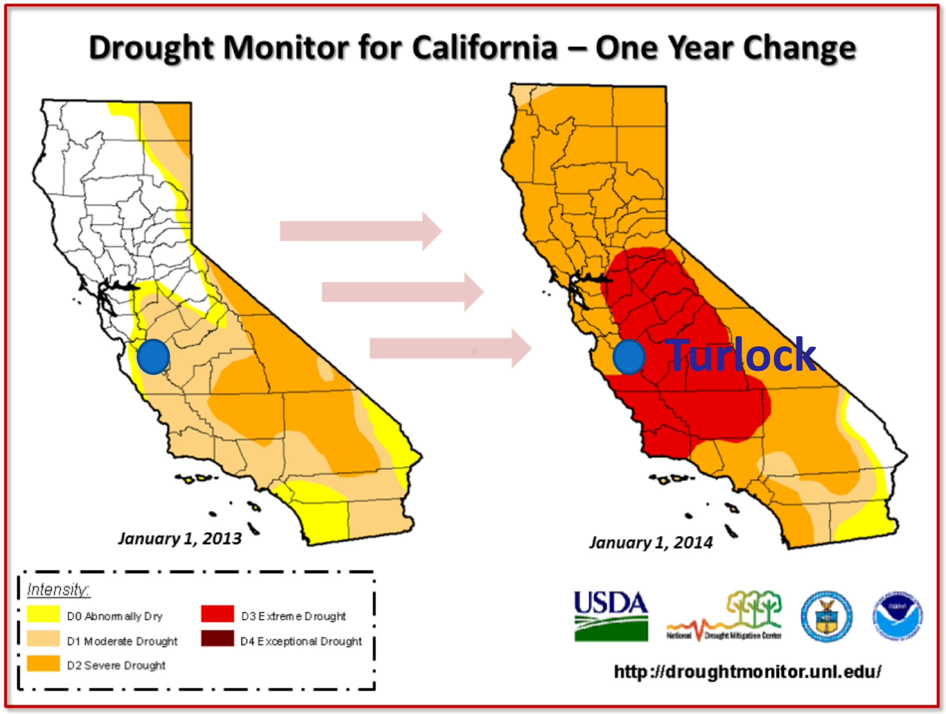
- California agriculture is $54 Billion industry; generates $100 Billion in economic activity
- California produces the most agricultural products of any state
- Forbes named agriculture as one of the top industries driving GDP growth in California
- 25%  of California is farmland
- 33% of America’s vegetables are from California, 67% are from the nation’s fruits and nuts




Source: California Department of Food & Agriculture, *California Agriculture Statistics Review 2012-2013*
Graphics: Modified from U. S. Census Bureau county maps

# Agriculture Depends on Water: Droughts

- U.S. agriculture accounts for 87% of fresh water use
- Severe droughts are increasing in commonality due to climate change
- Droughts lead to **severe** agriculture losses, job losses, decline in property value, and can have large effects on the community

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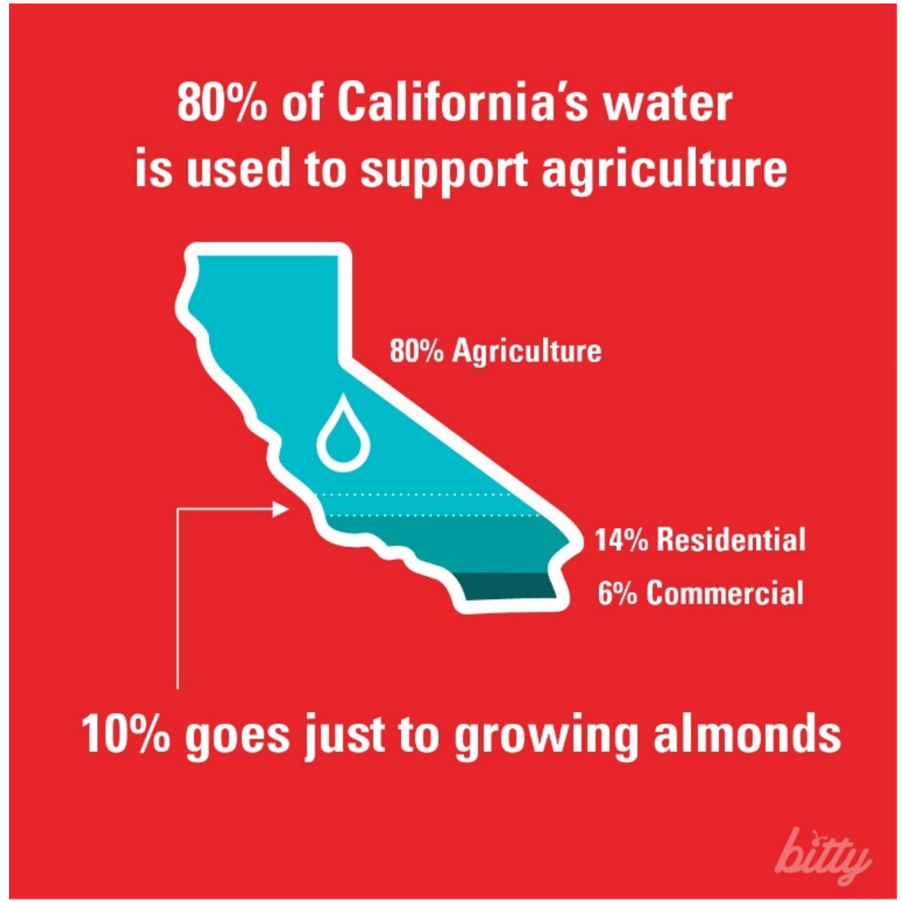
# Agriculture Depends on Water: Shortages

- California water diversion proposals decrease water reliability for agricultural products which could lead to **irreversible** damages



# Turlock Agriculture

- One-third of Turlock citizens work in agriculture (the highest percentage)
- Turlock ranks as one of the nation's top agricultural counties
- Produces $3.2 B in gross farm income
- Affordable and adequate water supplies enables a successful agricultural industry
- Centered in Stanislaus county, which includes 20% of state agricultural acres

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# Three Flawed River Flow Requirements

Flawed and incomplete proposals reduce water flow that adversely affects the agricultural economy

# Proposals & Water Flow

- Proposed river flow water reduction exacerbate severe drought conditions for 2014–2015:
  - NMFS –38.5%
  - USFWS –35.1%
  - CDFW –38.1%
- River flow restrictions during severe drought conditions lead to **irreversible** damages of tree crops—the agricultural foundation of Turlock
- As previous droughts have shown, insufficient water severely impacts areas outside of the agricultural industry

–>

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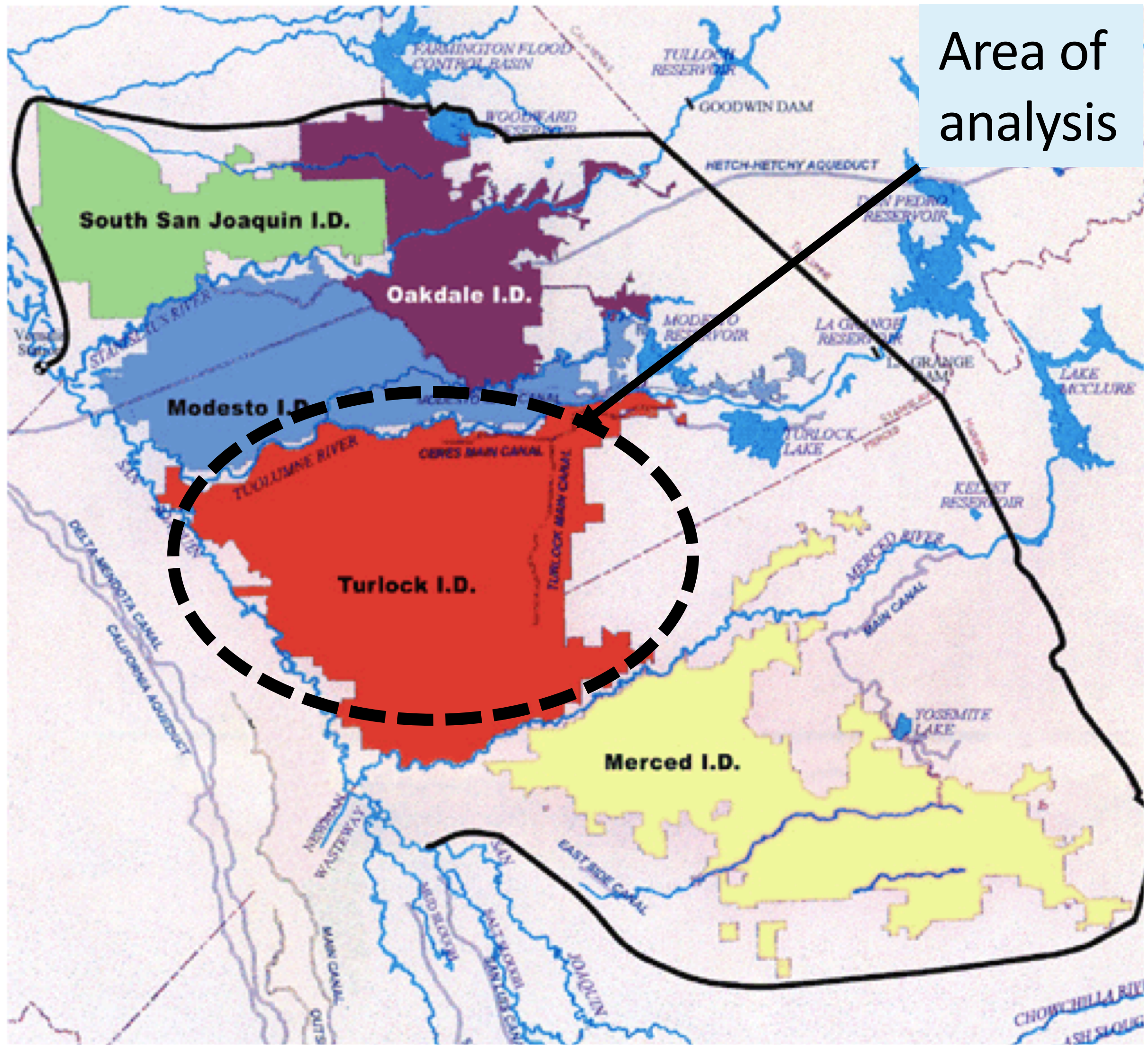
# Impacted Areas from Water Flow Reductions

- The three proposed river flow reductions impact flow requirements along the Tuolumne River
- Current analysis focuses on agricultural and other indirect impacts in TID exclusively



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# Critical Components to Valuing Economic Costs of Flow Restrictions

Three NMFS, USFWS, and CDFW proposals:

- **Disregard** that land in drought years often becomes permanently fallow or sustains irreversible damages to tree crops
- **Disregard** the permanent fallowing of land and destruction of tree crops
- **Do not** account for reduced lease rent of land and property
- **Do not** account for farms in TID less than 250 acres
- **Do not** account for diminished property value and lost taxes

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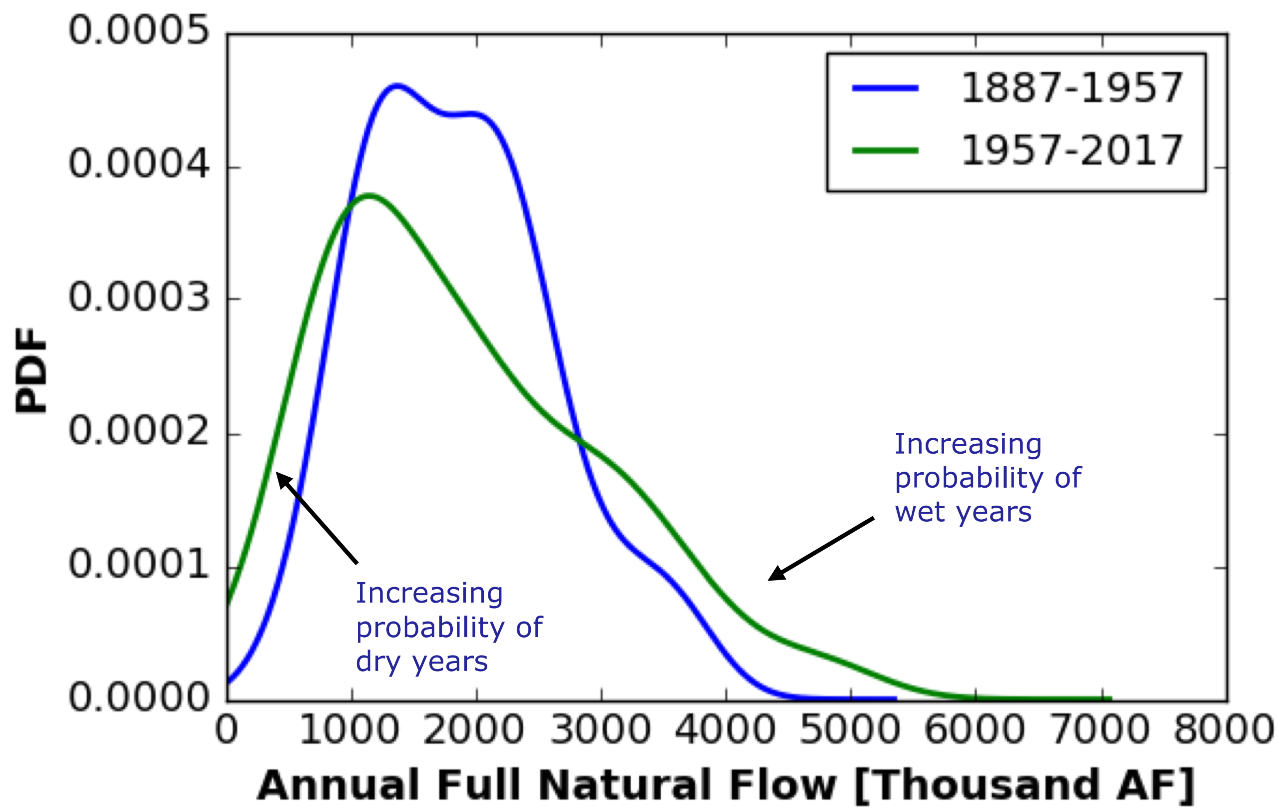
# Growing Variability of Water Flows

- Histogram of natural stream flows shows a significant departure in variability of flows since 1957
- With more frequent and intense droughts expected, TID will face a **greater loss in value to agriculture** under the proposed river flow requirements

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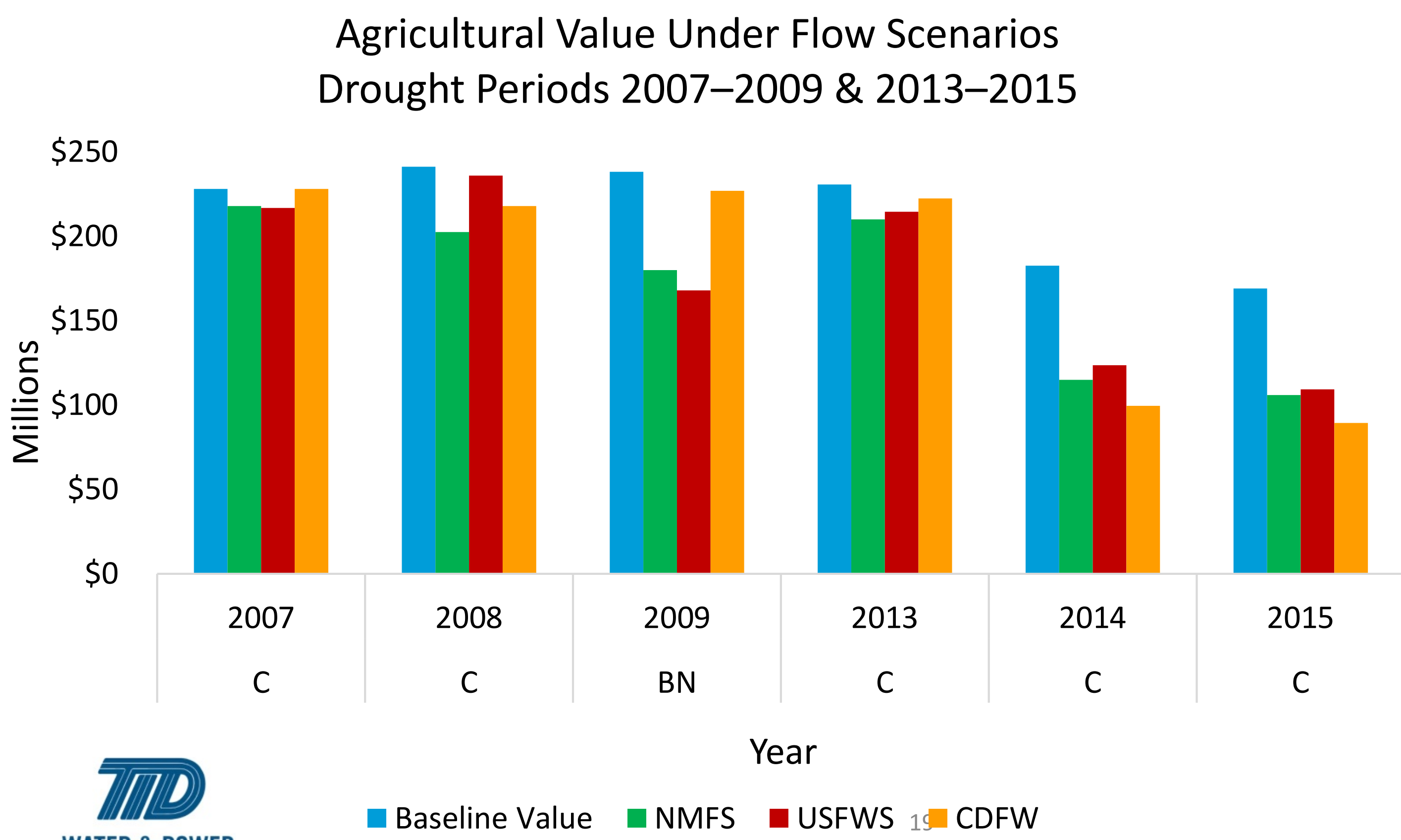
# Agricultural and Economic Consequences

Greater water variability leads to crop reductions and devaluation; agricultural losses; dairy losses; population migration; and property value, income, and revenue losses

# Losses in Crop Valuation

- Greatest damages to crops occur during multiyear droughts, **after** the first year of drought. Under the proposals, Don Pedro would typically have enough water reserves to reach current levels of water deliveries during a single drought year **only**
- Agriculture is hardest hit in the most critically dry years (2014–2015). Ascend assumes increased groundwater use in the worst years: **not** a long-term solution

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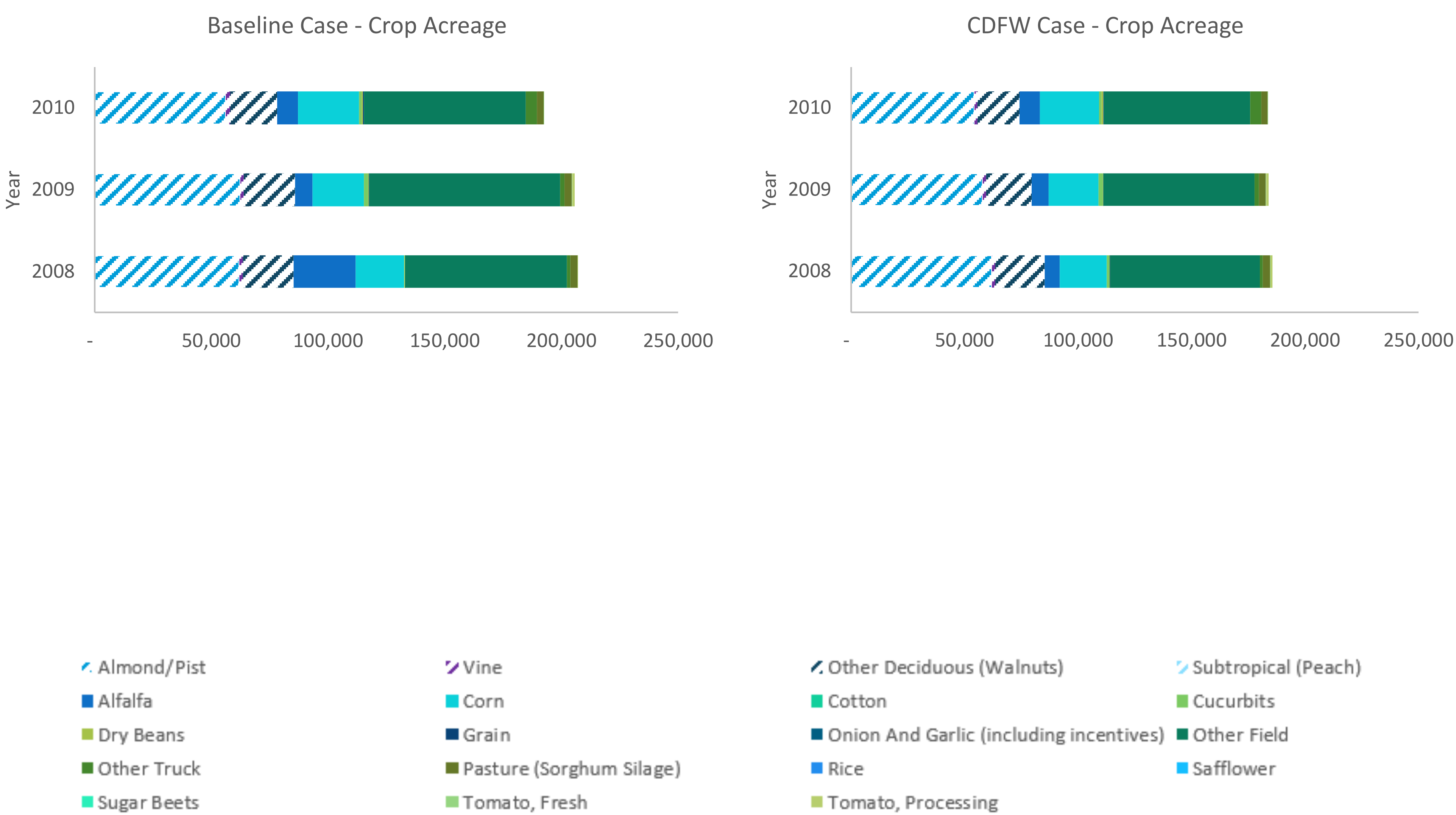
# Changing Crop Acreage (1 of 2)

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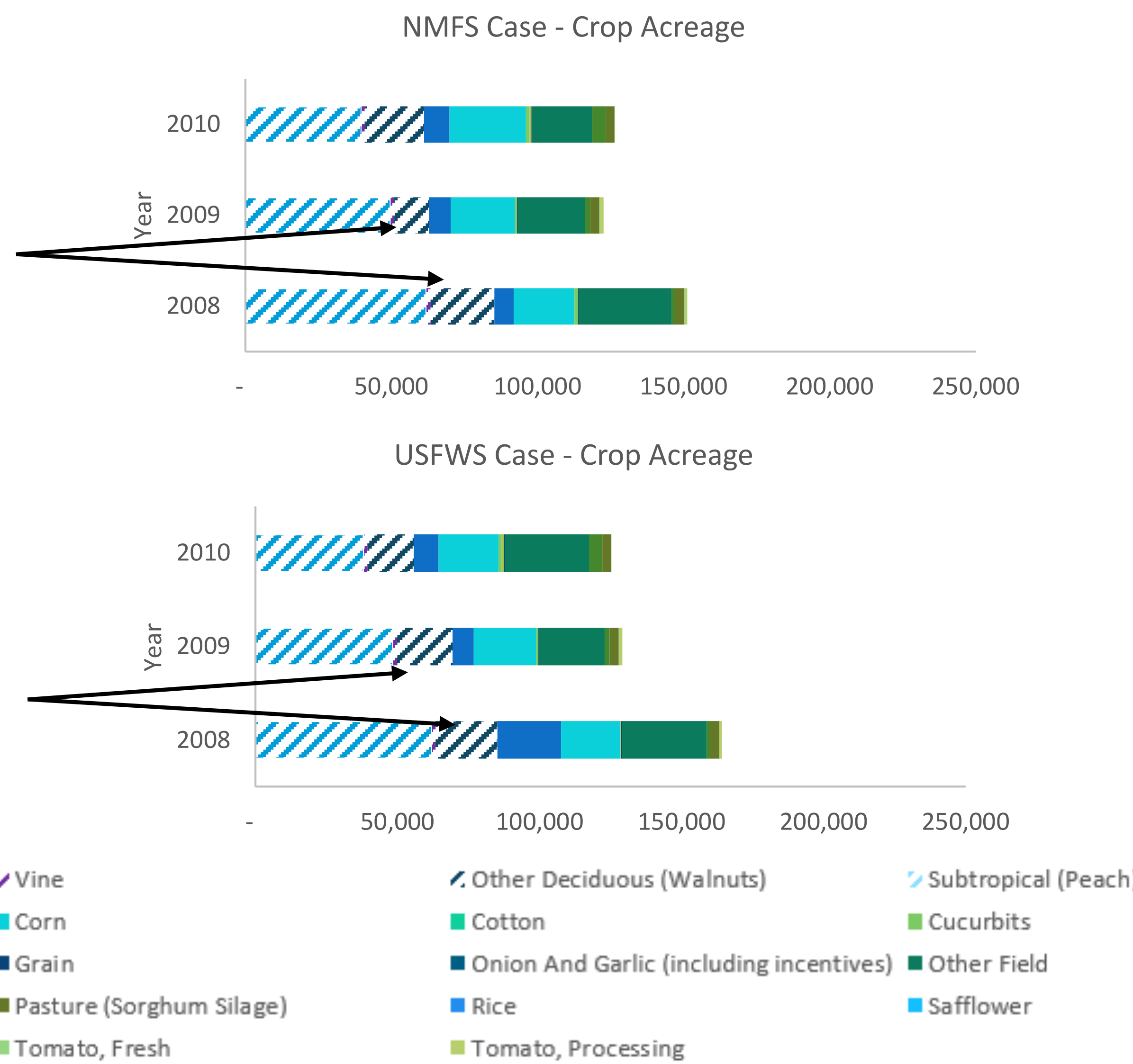
# Changing Crop Acreage (2 of 2)

- **Irreversible damage to permanent crops due to heavy flow restrictions**

- **Almond and Walnut crops never fully recover from damages**

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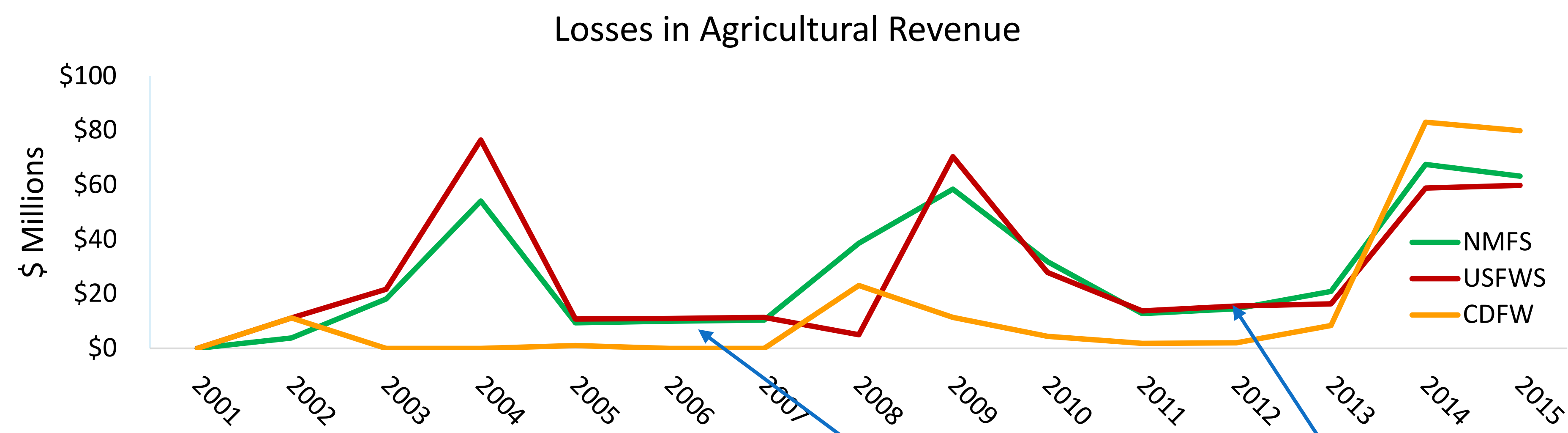
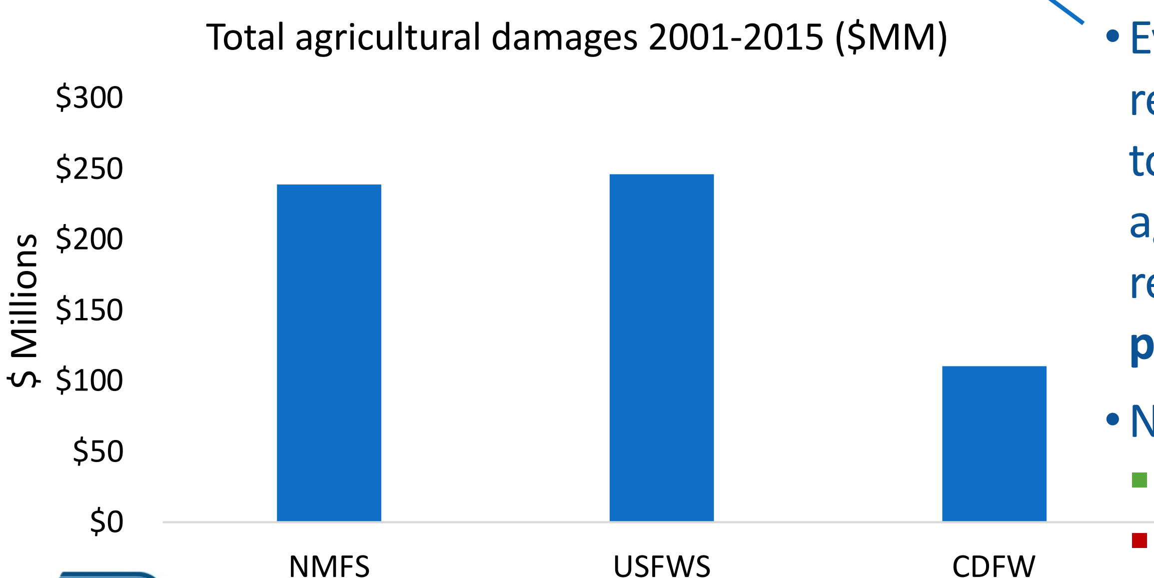
# Irreversible Losses in Agricultural Value from Damaged Trees

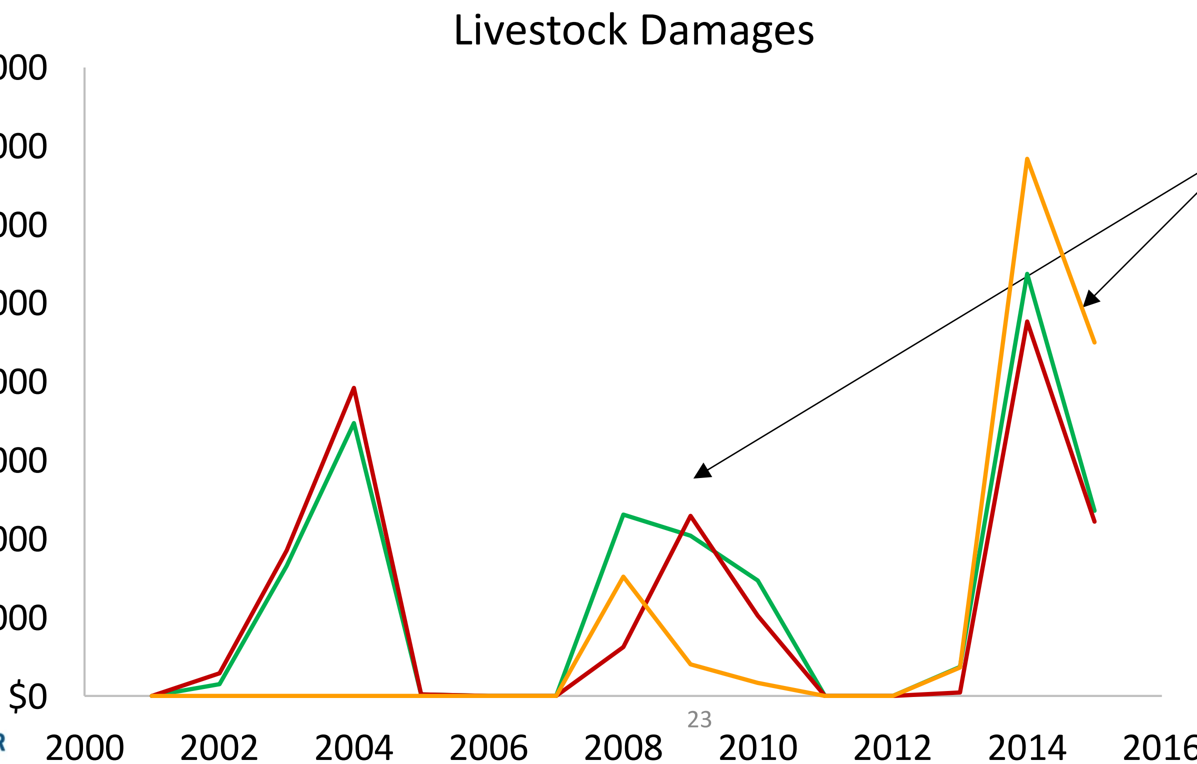



- Even in periods with little to no reductions in water deliveries relative to baseline, TID continues to **lose** agricultural output due to the residual losses of almond trees during **past drought years**
- NPV of **total losses** from 2001–2015:
  - NMFS = $239.2 MM
  - USFWS = $246 MM
  - CDFW = $111 MM

# Dairy Industry Effects

- Beef processing and milk processing are water intensive processes
- Water reduction across different flow scenarios will cause semi-permanent migration of dairy industry from Turlock
- Water requirement for dairy industry:
  - Milking cows - 115 L/day per cow
  - Feedlot beef cattle – 41 L/day per cow




High damages in Dry and Critically Dry years for dairy production

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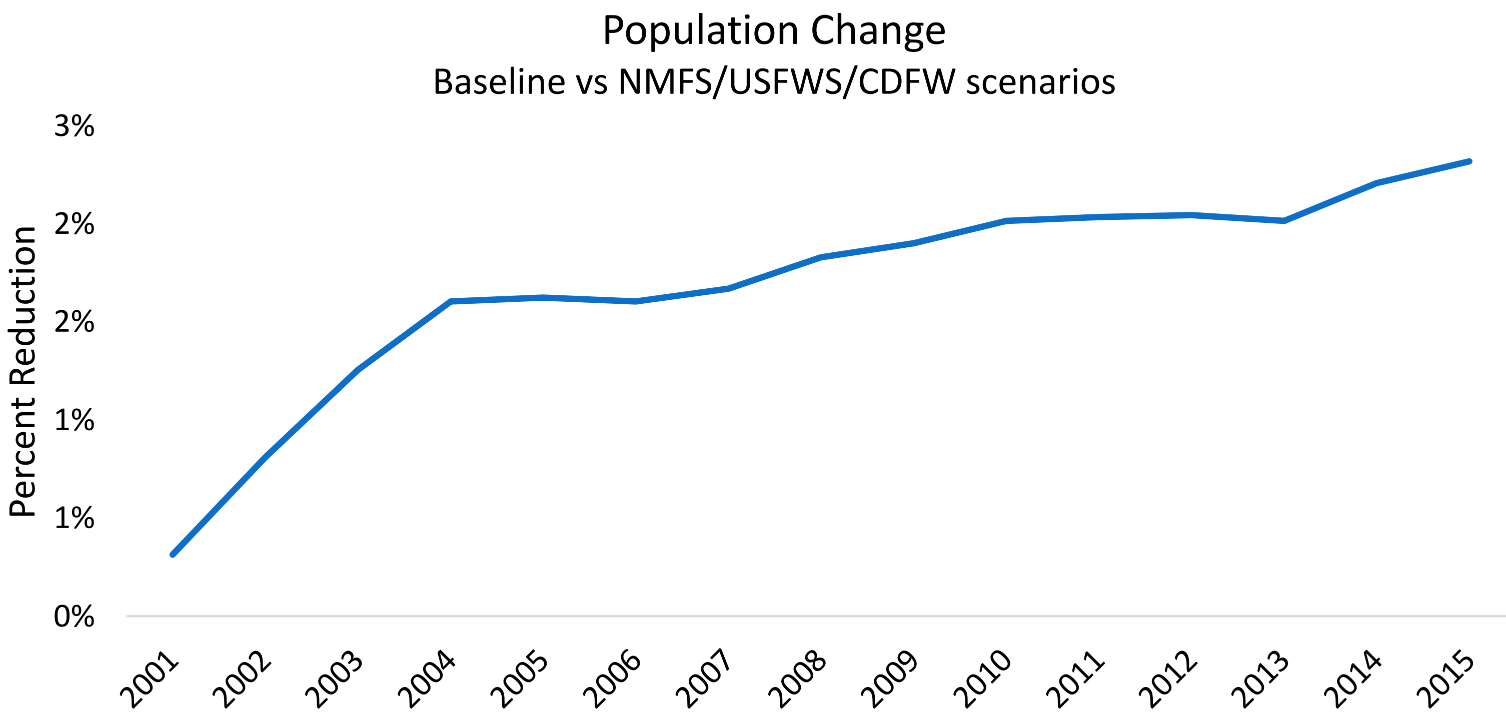
# Population Migration

- Tree crops are a primary economic driver of the region; their **persistent damage** during dry years causes downstream business opportunities erode
- Population migration occurs, with the reduction in population having a permanent effect on the regional economy

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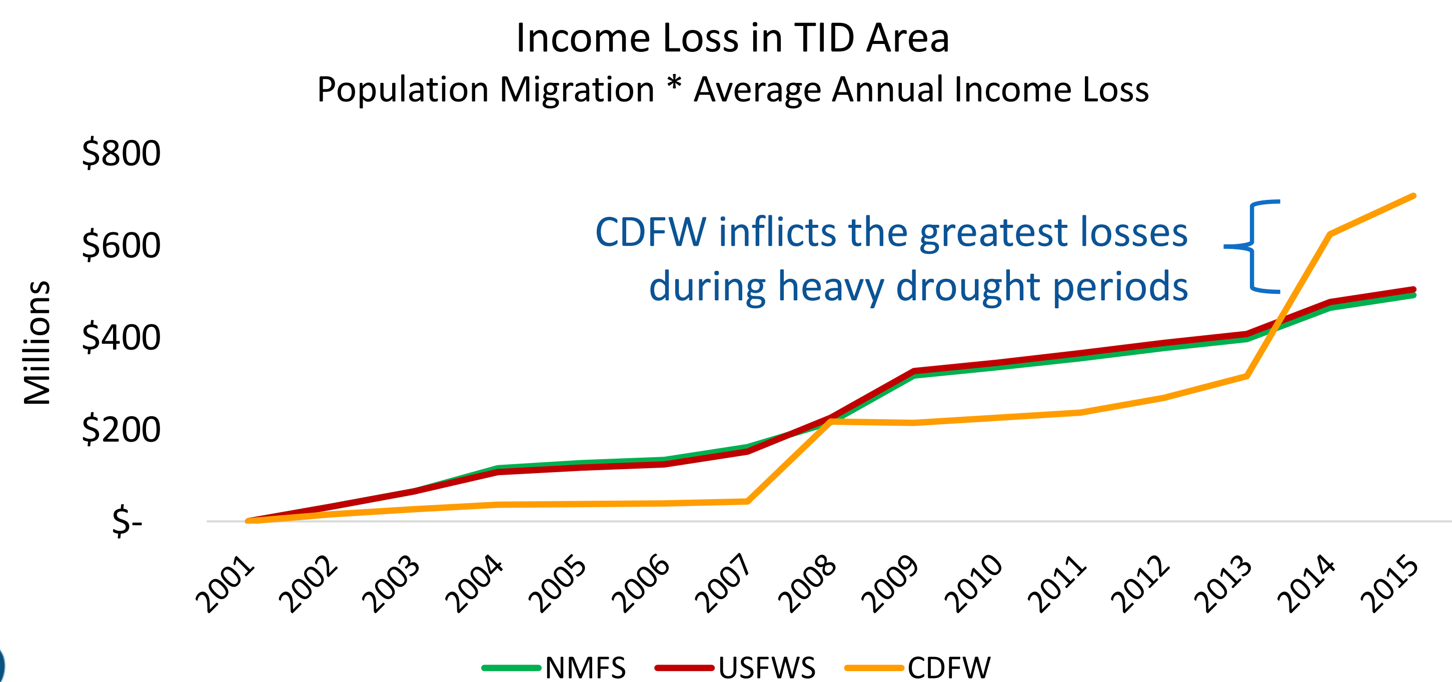
# Regional Income Loss

- The **loss in agricultural output** coupled with the decreasing population causes systemic **losses in income** to the region
- NPV of income over study period:
  - NMFS - $118 MM
  - USFWS - $119 MM
  - CDFW - $90 MM

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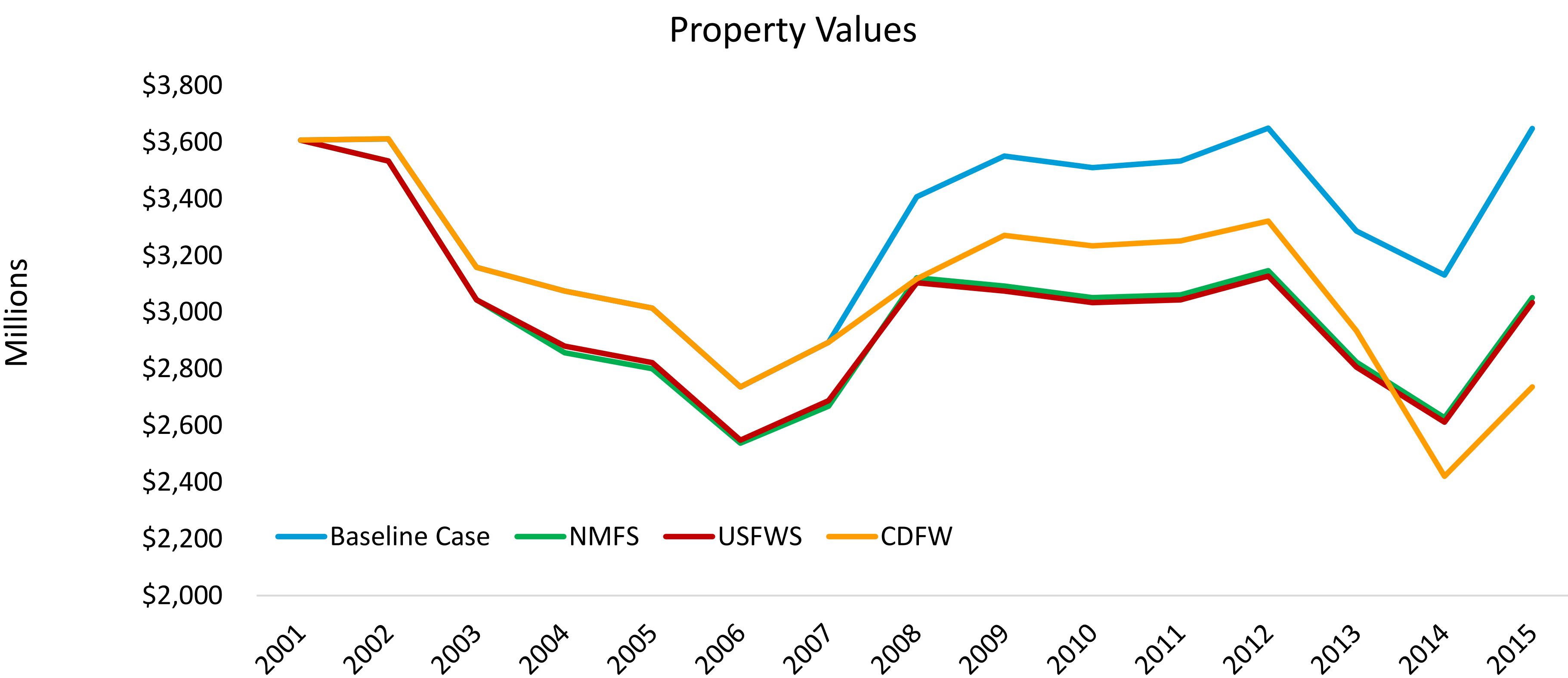
# Property Values Losses

- As a result of water reductions during multi-year droughts & the destruction of permanent crops**, property values decline and never rebound**

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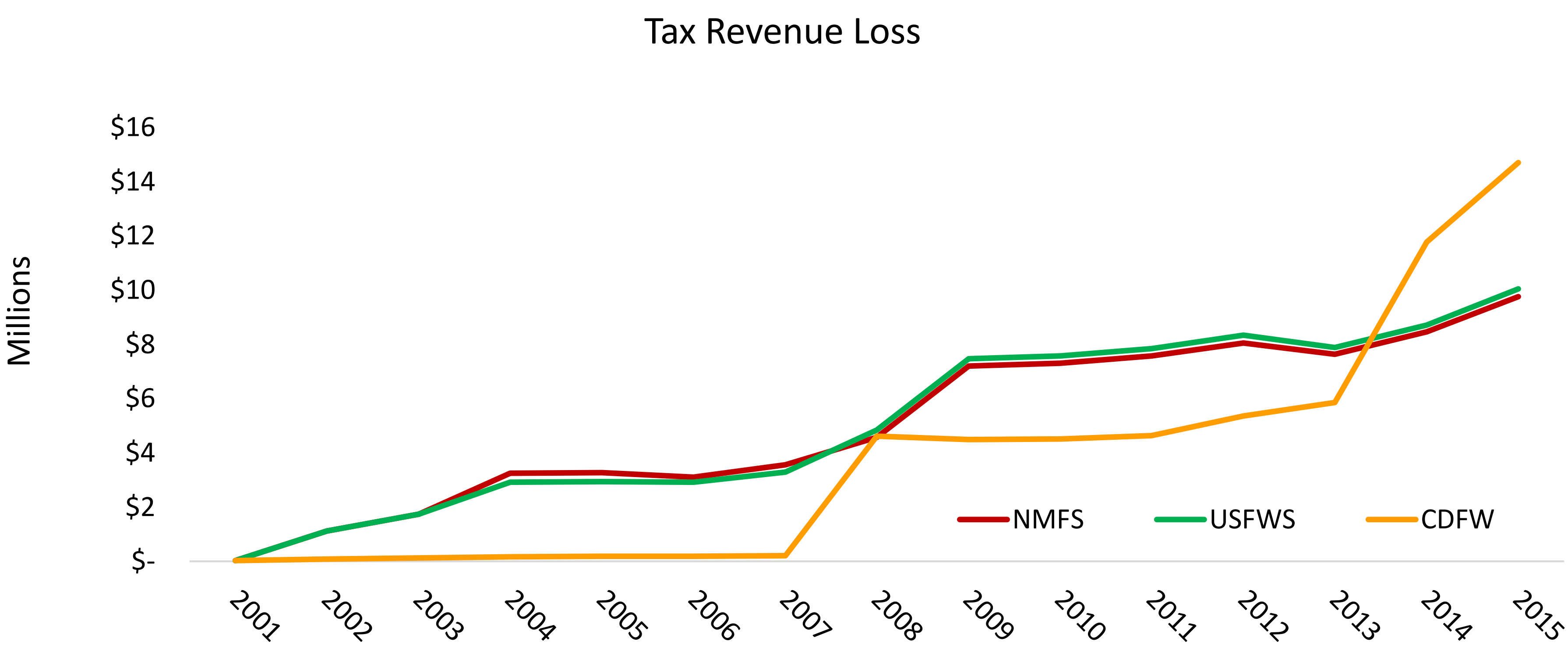
# Tax Revenue Losses

- Ascend estimates tax revenue to be 1.25% of property values and 7% of annual income



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# Financial Losses

$510 Million to $844 Million loss for the study period

$287 Million to $408 Million loss *annually*

# Total Damages by Proposed Restriction

| Damages under the Ascend Analysis (2001–2015) | | | |
|---|---|---|---|
| **Proposal** | NMFS | USFWS | CDFW |
| **Loss In Agricultural Profits** | $239 MM | $265 MM | $111 MM |
| **Loss in Total Income** | $118 MM | $120 MM | $90 MM |
| **Loss in Tax Revenue** | $39 MM | $39 MM | $25 MM |
| **Average Loss in Property Value** | $319 MM | $324 MM | $228 MM |
| **Dairy Industry Damages** | $104.4 MM | $95.6 MM | $56.2 MM |
| **Total Damages** | **$819.4 MM** | **$843.6 MM** | **$510.2 MM** |

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# Average Annual Losses

| Average Annual Damages (average year of flow restriction implementation) | | | |
|---|---|---|---|
| **Proposal** | **NMFS** | **USFWS** | **CDFW** |
| **Loss in Agricultural Revenue** | $27.6 MM | $27.3 MM | $15.1 MM |
| **Loss in Total Income** | $17.0 MM | $17.3 MM | $14.3 MM |
| **Loss in Tax Revenue** | $5.4 MM | $5.5 MM | $4.0 MM |
| **Loss in Property Value** | $342 MM | $346 MM | $245 MM |
| **Dairy Losses** | $13 MM | $11.4 MM | $9.2 MM |
| **Overall Average Annual Damages** | **$405 MM** | **$407.5 MM** | **$287.6 MM** |

# Conclusion

- Economic analysis of the current proposals **reveal a number of factors omitted**
- Deep analysis of the economic effect of increased water diversions clearly shows that it will lead to no economic or community benefits
- Given the **increasing variable climate**, water rights are necessary to ensure a sustainable future of agriculture and to allow for the agricultural sector to continue high contributions to the state of California
- Let’s keep California as the top producer of agriculture by **not** implementing water diversions. **Farmers deserve water rights!**


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# Extra Slides

- Methodology (2 slides)
- Methodology: analysis of ripple effects (2 slides)
- Turlock: one-third of population employed by agricultural industry
- UC Davis IMPLAN multiplier limitations
- Ascend analysis of ripple effect caused loss of agricultural output (6 slides)

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# Methodology (1 of 2)

- Ascend developed a general equilibrium model that determines damages through two phases, following a causality chain that explains how changes in explanatory variables affect response variables
  1. Econometrically modeling available irrigated acreage, based upon water inputs provided by TID's historical analysis
  2. Assessing agricultural revenue with a linear optimization model that maximizes yearly agricultural profits

# Methodology (2 of 2)

- Econometric model for irrigated acreage:

$$Irrigated\ acreage\ = \alpha + \beta_1 * temp + \beta_2 * applied\ water + \beta_3 * precipitation$$

  - Where $\alpha\ and\ \beta_i$ are regression coefficients

- The coefficients were determined from historically applied water, and irrigated land acreage sourced from Department of Water Resources (DWR); water diversions from TID's archives; published regional crop reports; as well as temperature and precipitation data from NOAA's National Climatic Data Center (NCDC)

- Then, a linear optimization model was used to maximize annual agricultural profits:

$$Annual\ agricultural\ profits = irrigated\ acres * yield * market\ price - production\ costs$$

- Subject to the following constraints:

$$Annual\ Water\ Availability \geq \sum Water\ requirement\ by\ crop\ type * Crop\ acreage$$

$$Annual\ Irrigated\ Land\ Availability \geq \sum Crop\ Acreage$$

$$Max\ acreage\ percentage\ increase\ (permanent\ crops) \geq Growth\ rate\ of\ permanent\ crops$$

- The above restraints account for risk-averse behavior to (re-)planting permanent water-intensive crops

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# Methodology: Analysis of Ripple Effects (1 of 2)

- Regional Income loss: Percent changes in irrigated acreage are superimposed as percentage changes in income losses resulting from direct losses of agriculture output from the acreage difference. Income losses are the difference of the product of population under the scenarios and expected average income
- Regional population change is then calculated by fitting an ARIMA model over historical regional population levels recorded during historical critical drought years
  - Accounting for the semi-permanent effects of migration, the ARIMA model incorporates a time-lagged "drift" term
  - The model does not immediately revert the population back to its original state after a large migration
  - The ARIMA with drift model is represented as:

$$\left(1-\sum_{i=1}^{p}\phi_i L^i\right)(1-L)^d X_t = \delta + \left(1+\sum_{i=1}^{q}\theta_i L^i\right)\varepsilon_t.$$

- $X_t$ is the time series data; $L$ is the lag term associated with the time series; p is the number of time lags; d is the degree of differencing; q is the moving average term; the $\alpha$ are the parameters of the autoregressive part of the model, the $\theta$ are the parameters of the moving average part, the $\epsilon$ are error terms and drift is represented by $\delta/(1 - \Sigma\varphi_i)$

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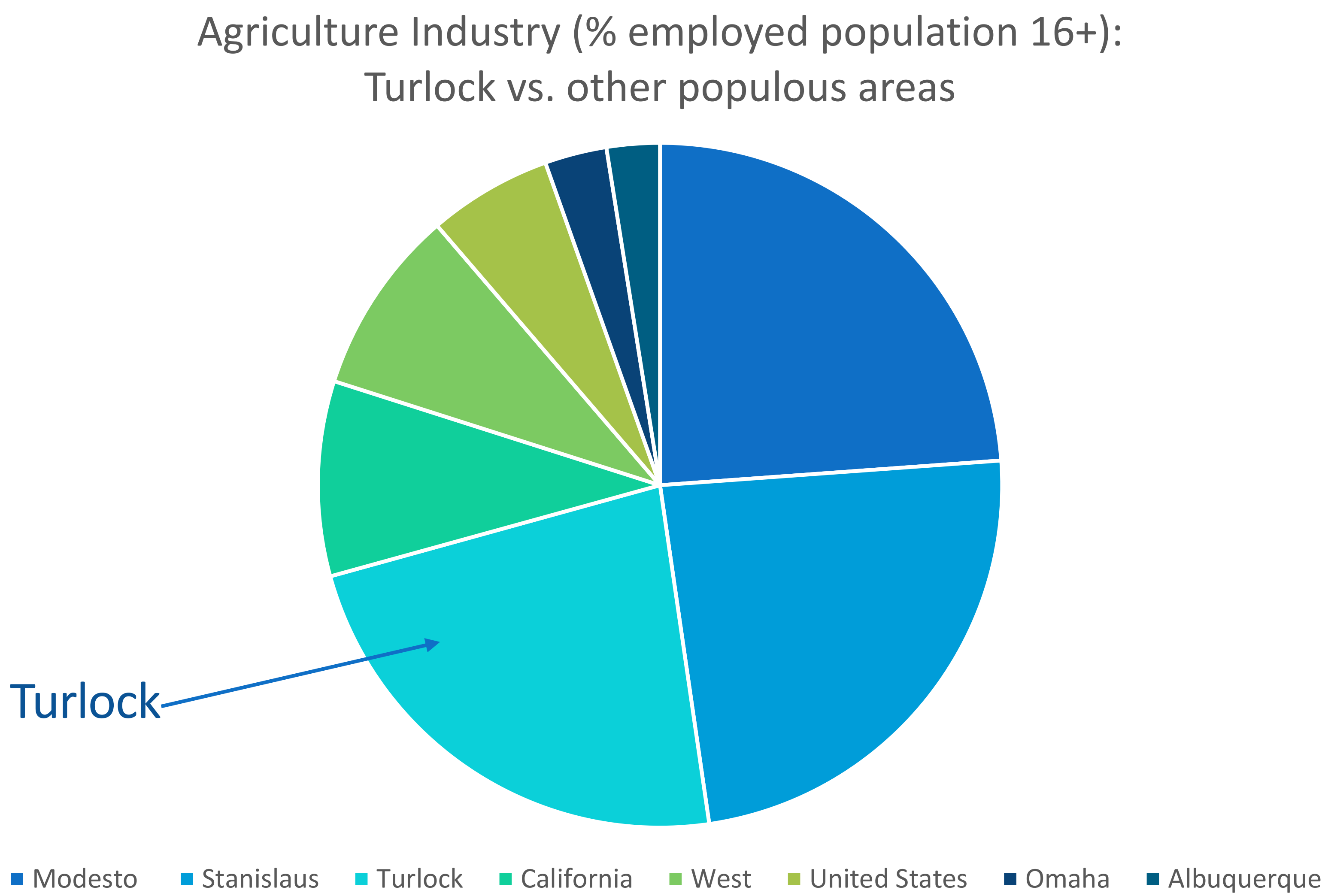
# Methodology: Analysis of Ripple Effects (2 of 2)

- Property value: The weight average of land values calculated by crop type

| Crop Type | Property Value ($/acre) | Crop Type | Property Value ($/acre) |
|---|---|---|---|
| Alfalfa | $ 19,024 | Other Truck | $ 19,024 |
| Almond/Pist | $ 49,305 | Pasture | $ 19,024 |
| Corn | $ 34,244 | Potato | $ 19,024 |
| Cotton | $ 19,024 | Rice | $ 20,927 |
| Cucurbits | $ 19,024 | Safflower | $ 23,020 |
| Dry Beans | $ 20,927 | Subtropical | $ 34,529 |
| Grain | $ 20,927 | Sugar Beets | $ 20,927 |
| Onion And Garlic | $ 19,024 | Tomato, Fresh | $ 28,537 |
| Other Deciduous | $ 34,974 | Tomato, Processing | $ 30,439 |
| Other Field | $ 19,024 | Vine | $ 53,716 |

- The year-by-year change in property valuation is calculated by fitting the ARIMA model to percentage changes in population for the baseline and the alternative cases
- Tax revenue: Calculated as 1.25% property value, and 7% of per capita income

# Turlock: one-third of population employed by agricultural industry



# Limitations with the UC Davis IMPLAN Multiplier

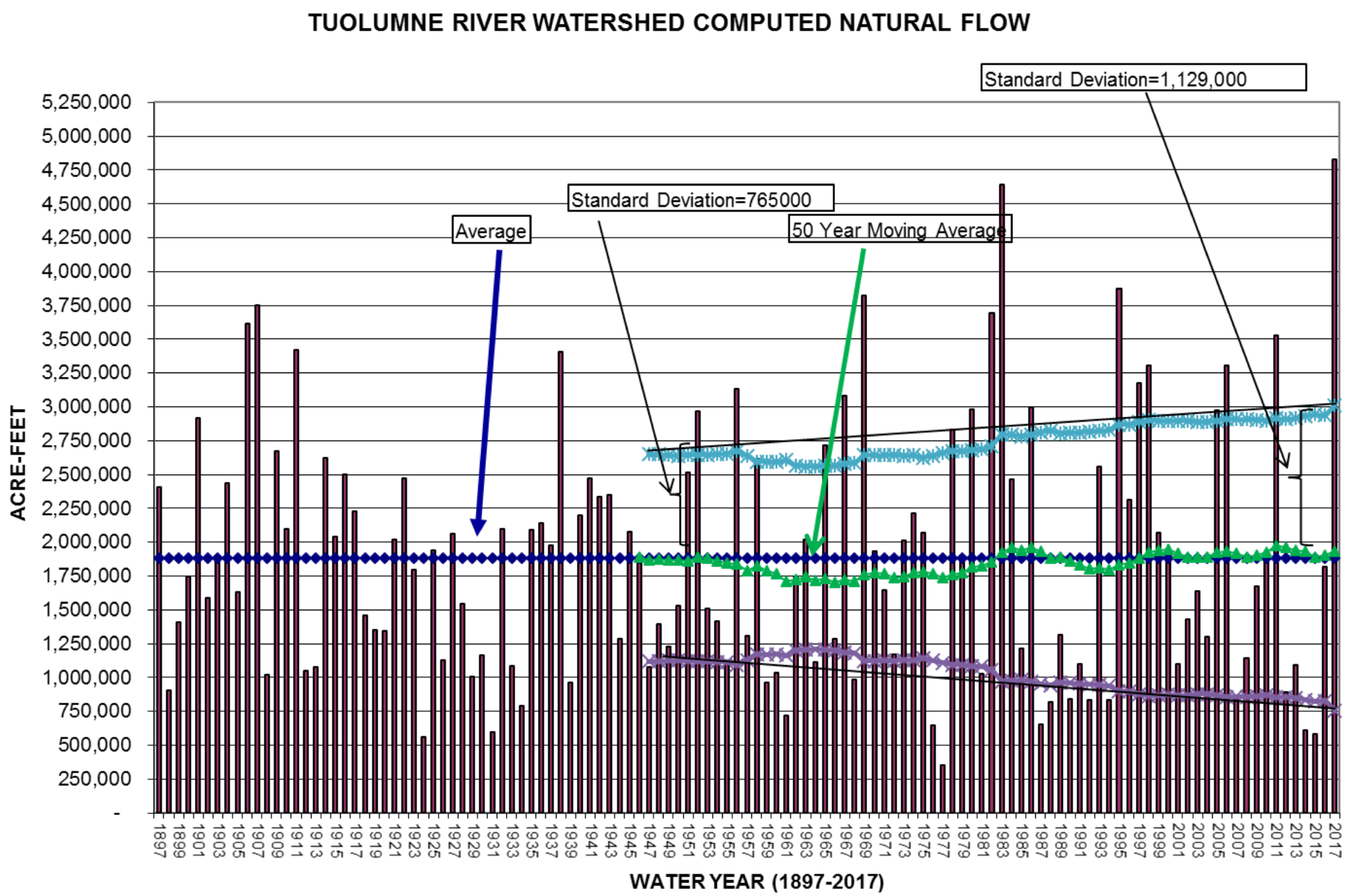
- IMPLAN multiplier **excludes** some forms of proprietor income: payments to households from interest, rents, royalties, dividends and corporate profits
  - These are key parts of many farmers' incomes
- Does **not** adequately capture expenditure patterns of mid-level and small agricultural operations that participate more directly in local and regional food systems.
  - In TID, approximately 55% of farms are 100 acres or less and 20% are between 100 and 250 acres
- Does **not** adequately account for adjustments that growers and the supporting economy would have to make with new restrictions
  - For example, a smaller dairy operation will likely not be able to switch to a sorghum operation in the short-term
- Does **not** take into account market conditions and forward-looking decisions by economic actors
  - The water reductions in question lead to enduring losses caused by policy, rather than the temporary losses caused by droughts

# Ascend Analysis: Ripple Effects

The following slides presents Ascend's analysis of the ripple effects caused by the loss in agricultural output

# Growing Variability of Water Flows

- Variability in natural flows is continuing to increase through time
- There is a **higher probability** of Dry and Critically Dry Years in the future



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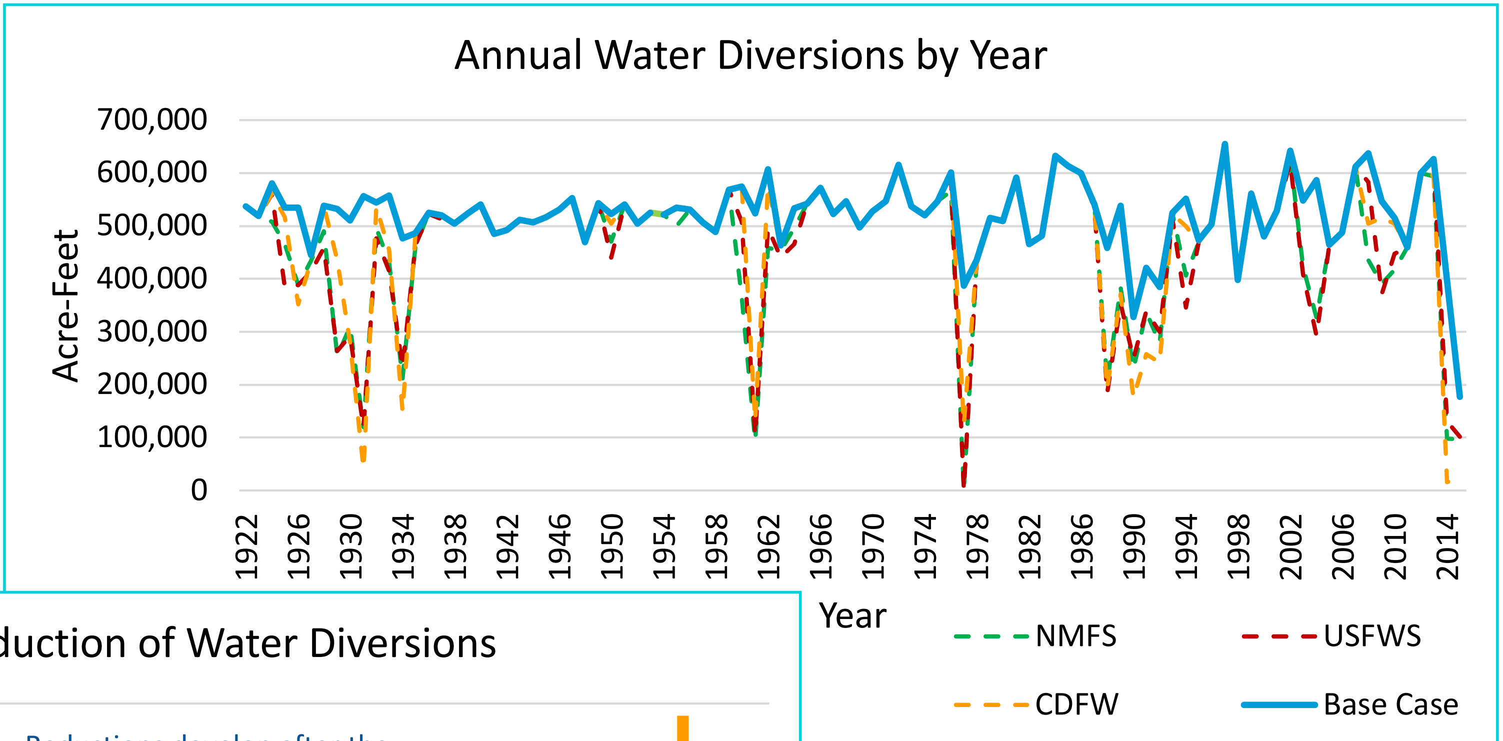
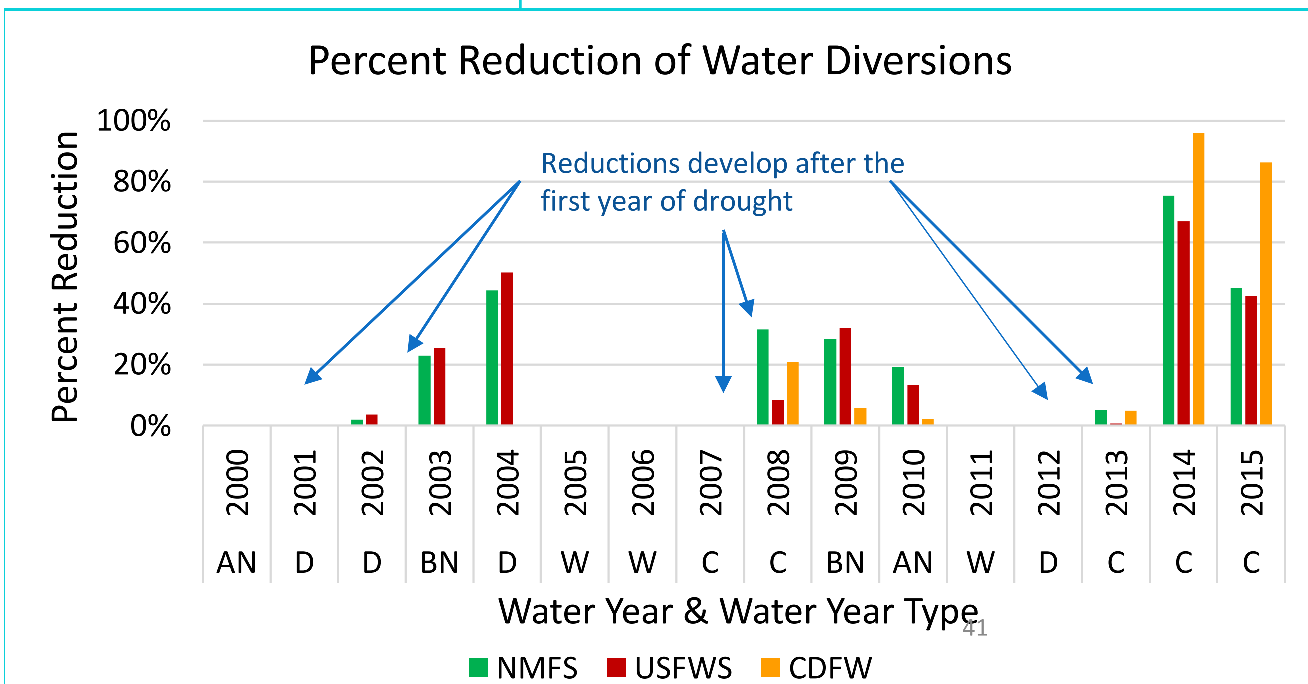
# Percent Reduction Under Proposed Flow Schedule: Historical Analysis (1922–2015)

- The worst water reductions under the proposals occur in multiyear droughts




- In particularly harsh drought years (1977, 2014), reductions can reach 95%–100%

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# Reduction of Water Under Proposed Flow Schedules: Historical Analysis (1922–2015)

- Water diversions impact are punishing during critically dry years

| | Percent Reduction of Water Diversions by Water Year Type (1922–2015) | | |
|---|---|---|---|
| **Water Year Type** | **NMFS** | **USFWS** | **CDFW** |
| **Average Wet Years (W)** | 0% | 0.2% | 0.1% |
| **Average Above Normal Years (AN)** | 2.2% | 2.5% | 0.5% |
| **Average Below Normal Years (BN)** | 7.7% | 9.6% | 1.2% |
| **Average Dry years (D)** | 7.3% | 8.0% | 3.5% |
| **Average Critically Dry Years (C)** | 38.5% | 35.1% | 38.1% |
| **Average All Years** | 11.3% | 11.1% | 9.4% |

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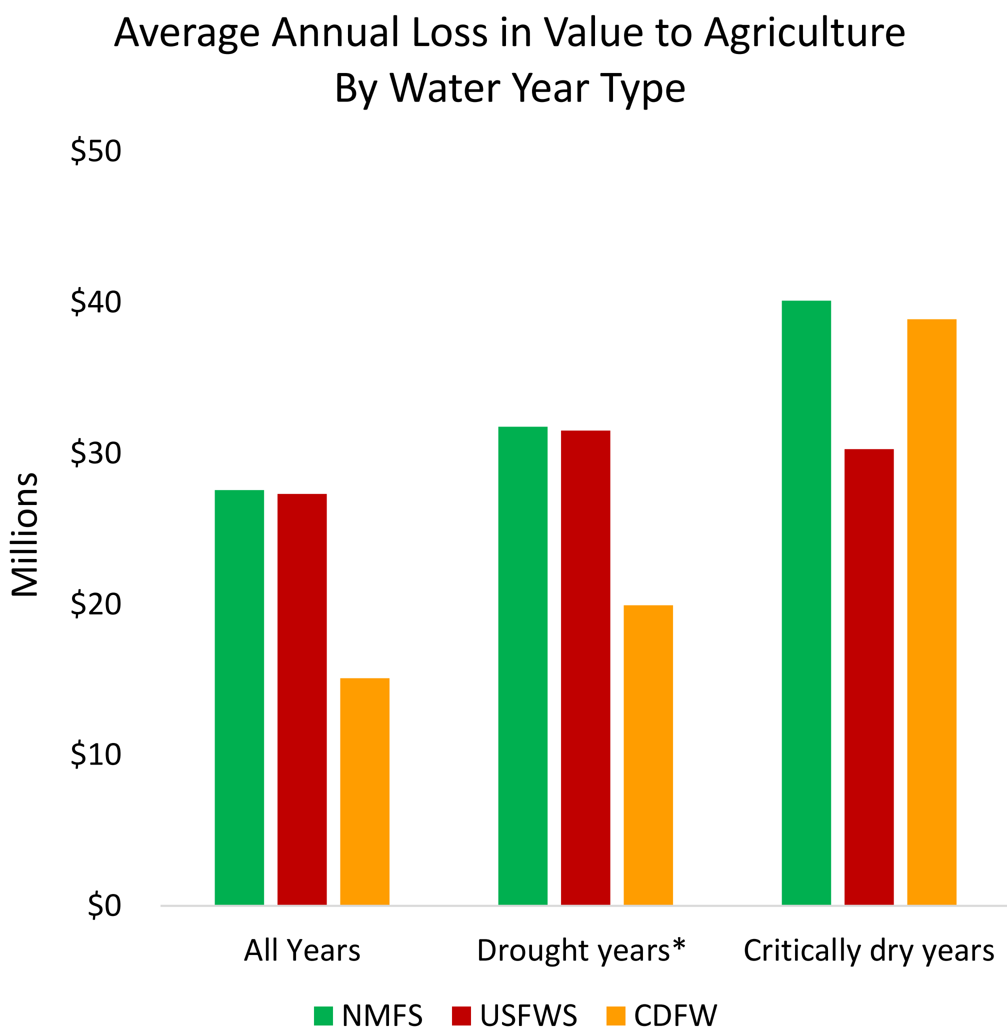
# Annual Losses in Agricultural Revenue




| Average Annual Losses in Agricultural Revenue ($ MM) | | | |
|---|---|---|---|
| **Proposal** | **NMFS** | **USFWS** | **CDFW** |
| **All Years** | $27.6 MM | $27.3 MM | $15.1 MM |
| **Drought Years** | $31.8 MM | $31.5 MM | $19.9 MM |
| **Critically Dry Years** | $40.1 MM | $30.3 MM | $38.9 MM |

*Drought years defined as Critically Dry, Dry, and Below Normal Water years

# Standard Calculations in Proposals Total Losses

- UC Davis IMPLAN Multiplier is a standard method used to calculate overall damages in agricultural proposals NMFS, USFWS, CDFW

| Overall Damages (2001–2015) with UC Davis Regional Multiplier | | | |
|---|---|---|---|
| **Proposal** | **NMFS** | **USFWS** | **CDFW** |
| **Loss in Agricultural Revenue (NPV)** | $239 MM | $246 MM | $111 MM |
| **Indirect and Induced Losses in Economic Value (Using IMPLAN Multiplier for Indirect impacts)** | $230 MM | $236 MM | $106 MM |
| **Overall Damages** | **$469 MM** | **$482 MM** | **$217 MM** |

UC Davis, Measure of California Agriculture, (2009),http://aic.ucdavis.edu/publications/moca/moca09/moca09.pdf.

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# Annual Losses with UC Davis Regional Multiplier

## Overall (NPV) Annual Damages with UC Davis Regional Multiplier

| Proposal | NMFS | | USFWS | | CDFW | |
|---|---|---|---|---|---|---|
| Water Year Type | Average Year | Drought Year* | Average Year | Drought Year | Average Year | Drought Year |
| Loss in Agricultural Revenue | $27.6 MM | $31.8 MM | $27.3 MM | $31.5 MM | $15.1 MM | $19.9 MM |
| Indirect Losses (IMPLAN multiplier) | $26.5 MM | $30.5 MM | $26.2 MM | $30.3 MM | $14.5 MM | $19.1 MM |
| **Overall Annual Damages** | **$54.1 MM** | **$62.3 MM** | **$53.6 MM** | **$61.8 MM** | **$29.6 MM** | **$39.1 MM** |

*Drought years defined as Critically Dry, Dry, and Below Normal Water years

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